that both actions occur, but the latter seems to me the true explanation; for if the first was alone true, we should have a far greater effect from metal powder, carbon, or some elastic conductor as metallised silk, than from gold or other hard unoxidisable matter; but as the best results as regards the human voice were obtained from two surfaces of solid gold, I am inclined to view with more favour the idea that an infinite change of fresh contacts brought into play by the molecular pressure affords the true explanation. It has the advantage of being supported by the numerous forms of microphone I have constructed, in all of which I can fully trace this effect.

I have been very much struck by the great mechanical force exerted by this uprising of the molecules under sonorous vibrations. With vibrations from a musical box two feet in length I found that one ounce of lead was not sufficient on a surface of contact one centim. square to maintain constant contact; and it was only by removing the musical box to a distance of several feet that I was enabled to preserve continuity of current with a moderate pressure. I have spoken to forty microphones at once, and they all seemed to respond with equal force. Of course there must be a loss of energy in the conversion of molecular vibrations into electrical waves, but it is so small that I have never been able to measure it with the simple appliances at my disposal. I have examined every portion of my room—wood, stone, metal, in fact all parts, and even a piece of India-rubber—all were in molecular movement whenever I spoke. As yet I have found no such insulator for sound as gutta-percha is for electricity. Caoutchouc seems the best; but I have never been able, by the use of any amount at my disposal, to prevent the microphone reporting all it heard.

The question of insulation has now become one of necessity, as the microphone has opened to us a world of sounds, of the existence of which we were unaware. If we can insulate the instrument so as to direct its powers on any single object, as at present I am able to do on a moving fly, it will be possible to investigate that object undisturbed by the pandemonium of sounds which at present the microphone reveals where we thought complete silence prevailed.

I have recently made the following curious observation:—A microphone on a resonant board is placed in a battery-circuit together with two telephones. When one of these is placed on the resonant board a continuous sound will emanate from the other. The sound is started by the vibration which is imparted to the board when the telephone is placed on it; this impulse, passing through the microphone, sets both telephone-discs in motion; and the instrument on the board, reacting through the microphone, causes a continuous sound to be produced, which is permanent so long as the independent current of electricity is maintained through the microphone. It follows that the question of providing a *relay* for the human voice in telephony is thus solved.

The transmission of sound through the microphone is perfectly duplex, for if two correspondents use microphones as transmitters and telephones as receivers, each can hear the other, but his own speech is inaudible; and if each sing a different note no chord is heard. The experiments on the deaf have proved that they can be made to hear the tick of a watch, but not, as yet, human speech distinctly; and my results in this direction point to the conclusion that we only hear ourselves speak through the bones and not through the ears.

However simple the microphone may appear at first glance, it has taken me many months of unremitting labour and study to bring to its present state through the numerous forms each suitable for a special object. The field of usefulness for it widens every day. Sir Henry Thompson has succeeded in applying it to surgical operations of great delicacy, and by its means splinters, bullets, in fact all foreign matter, can be at once detected. Dr. Richardson and myself have been experimenting in lung- and heart-diseases, and although the application by Sir H. Thompson is more successful, I do not doubt but that we shall ultimately succeed. There is also hope that deafness may be relieved, for telephony articulation has become perfect and the loudness increased. Duplex and multiplex telegraphy will profit by its use, and there is hardly a science where vibrations have any direct or indirect relation which will not be benefited. And I feel happy in being able to present this paper on the results obtained by a purely physical action to such an appropriate and appreciative body as the Physical Society.

In conclusion, allow me to state that throughout the whole of my investigations I have used Prof. Bell's wonderfully sensitive telephone instrument as a receiver, and that it is thanks to the discovery of so admirable an appliance, that I have been enabled to commence and follow up my researches in microphony.

LABORATORY NOTES

DURING the daily routine of life in a laboratory many observations are made of an isolated character, perhaps having no direct bearing on the subject in hand, but which, nevertheless, may be eminently suggestive to other minds. The record of such observations are often lost; they are not communicated unless they find a place in a larger research, and they go to form the capital which every worker is accumulating till his death, much of which, unfortunately, perishes with him. I therefore cordially approve of the suggestion of the Editor that workers in the various departments of experimental science should occasionally write a few notes containing a brief account of any observations recently made, and I shall be glad to contribute my quota.

1. *Carl Zeiss' New Oil Immersion Lens.*—This is a ⅛th-objective, on the immersion system, in which the fluid used is oil of cedar-wood. For amount of light, clearness of definition, resolving power, and flatness of field, it is superior to any lens I have worked with. For use in histological observation, it does not require any special arrangement of light. In examining such objects as blood-corpuscles or salivary cells with very high powers it is of great advantage to be able to use cover-glasses of ordinary thickness, and to have a serviceably-working distance. This is secured by Zeiss' lens. I have found that, with ordinary Nos. 6 and 7 Hartnack-objectives, more light is obtained by using them as immersion-lenses with a drop of equal parts of oil of cedar-wood and olive oil. The method of using fluids of high refractive index, on the immersion principle, seems to me likely to lead to valuable results. With oblique light, cutting off light from the mirror, the performance of Zeiss' lens is remarkably good.

2. *The Phonograph as a Transmitter.*—By placing Hughes' microphone on the disc of the phonograph the latter will transmit the sounds recorded on the tinfoil to a telephone at a distance. Thus we have a combination of microphone, phonograph, and telephone, which promises to be of use. It is very suggestive to hear the phonograph speaking in one room and to know that some one else in another room, or at a long distance off, is also hearing a repetition of the sound. I have no doubt that arrangements might be made by which the sound might be reproduced in a dozen different places at once.

3. *The Working of the Phonograph.*—After a good deal of experience I have come to the conclusion that a thin and slightly elastic membrane is the most suitable for loudness, whilst a rigid non-elastic membrane is most adapted for distinctness. From a consideration of the histological structure of the drum of the ear this is what one would expect. After the impressions have been made on the tinfoil, distinct speech, in a feeble voice, of most peculiar quality, like what one would imagine to be the tones of the fairies of old, can be heard from one of Marey's tambours, by bringing the point of the lever on the surface of the phonographic cylinder. With this method there is almost no friction, and consequently the marks on the tin-foil are not quickly rubbed out. By connecting a tube with the tambour and carrying it from the tambour to the ear, sounds may be heard, even as speech, after the marks have been so erased from the tinfoil as to be scarcely perceptible to the eye. Thus the tambour, when so used, may be said to be a microphone.

4. *The Microphone.*—I have tried many experiments with the ingenious arrangement of Mr. Hughes, and have been much impressed with its extreme sensitiveness. It may be used to make and break at pleasure the primary coil of the induction machine. When fixed to the box of a monochord the slightest touch of the wire with a camel-hair pencil sounds loudly in the distant telephone. When placed on the sounding-board of a piano, I have heard distinctly a complicated piece of music eighty yards away; when attached to the throat by an india-rubber band, the faintest trill or whisper is audible; and it transmits the muscular sound from a powerful biceps.

5. *A Lecture Experiment.*—Place the heart of a frog on the electrodes of Du Bois-Reymond in connection with a sensitive reflecting galvanometer. The rhythm of the pulsations may then be observed by the swinging to and fro of the spot of light on a transparent screen. This has often been observed by

physiologists, but, considered as a lecture experiment, it is very instructive.

6. *The Sensibility of the Telephone to Feeble Currents.*—As an example of this, I may instance the following experiment:—The gastrocnemius muscle of a frog was placed on the non-polarisable electrodes of Dubois Reymond, so that the transverse section touched the one electrode, and the longitudinal surface the other; the current thus obtained, when sent through a reflecting galvanometer, was sufficient to drive the spot of light from end to end of the scale, placed about three feet in front of the galvanometer; the galvanometer was then disconnected, and a telephone placed in circuit; it was then found that on making and breaking the current, a faint but sharp click of the telephone plate was heard. No click could be heard when the muscle was removed and the two electrodes were connected with a bit of moist blotting paper. The muscle current was therefore sufficient to act on the telephone. The click was stronger when the muscle was placed in contact with two platinum terminals, and when a small carbon microphone was also placed in circuit. I then tried to ascertain whether any effect on the click could be produced by throwing the muscle into a state of tetanus, and I found that in these circumstances no click could be heard at all. In other words, during the state of muscular contraction the muscle current was so diminished (the *negative variation* so called) as to be unable so to affect the telephone as to produce audible sounds. The telephone thus was used instead of the galvanometer in a physiological experiment.

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Physiological Laboratory,
University of Glasgow, June 17

VOLCANIC PHENOMENA AND EARTHQUAKES DURING 1877

ALTHOUGH the most important results from the statistics of volcanic phenomena and earthquakes are obtained only if the observations and records spread over a period of many years, yet a number of interesting facts are revealed even in the compilation of the phenomena which occur during a single year. Prof. C. W. C. Fuchs is most indefatigable in these compilations, and he has recently published his statistical account of eruptions and earthquakes for the year 1877. From this we note the following details:—

During 1877 five important eruptions of different volcanoes took place. The eruption of the South American volcano Cotopaxi which lasted from June 25 to 28, was of a most characteristic nature for this mountain. According to the phenomena by which it was accompanied, it must be designated as an eruption of ashes and mud. Although Alexander von Humboldt's view, that the South American volcanoes do not produce lava, has been refuted long ago (Cotopaxi sent forth a copious stream of lava in 1853) yet the most frequent eruptions from this mountain are those of ashes only, without a flow of lava. Streams of mud are often combined with eruptions of this kind, and have different causes; in 1877 they particularly devastated the valleys of Chila and of Tumbaco, and in the former many hundreds of lives were lost through them. The ashes which the volcanos ejected so filled the air that complete darkness reigned everywhere, and the dust was so fine that it entered even into the interior of houses, although the doors and windows were shut.

The most violent eruption of 1877 occurred upon the island of Hawaii. Twice interrupted, the lava forced its way to the surface in three different places, and thus furnished the most undeniable proof that one and the same bed or hearth of lava, may produce eruptions in any of the numerous craters of Hawaii, according to time and circumstances. The first part of the eruption occurred on February 14 from a little side crater close to the summit of Mauna Loa; its duration was six hours, and the height of the column of smoke, which assumed the shape of an Italian pine-tree, was estimated at 5,000 metres. The second part occurred on February 24, in the Bay of Kalukeakua, well known as the place in which Cook, the great discoverer of the Sandwich Islands, was assassinated. This eruption was submarine, and lasted two days; its seat was in the middle of the bay, which is surrounded by numerous prehistoric records of its volcanic nature. On May 4 the lava found its usual way to the surface through the lava lake of Kilauea, which has solidified for some time. Here the wonderful phenomenon of high jets of lava occurred, a phenomenon which is peculiar to this spot only. During a period of six hours, now here, now there, vast jets liquid lava rose from the ground, and their number was so great that at one time more than fifty simultaneous ones were counted, some reaching an altitude of thirty metres.

The third eruption was that of the small Japanese island-volcano, Ooshima, and lasted from January 4 to February 6 or 7. Violent subterranean noise and disastrous earthquakes accompanied the volcanic phenomena, particularly on January 20 and on February 4 and 5.

On June 11 an eruption occurred in a volcanic district almost unknown hitherto, viz., near the Colorado River in Southern California, at some sixty miles' distance from Fort Yuma. The last eruption was a submarine one, and happened on June 15, near the Peruvian coast.

The number of earthquakes during 1877, of which Prof. Fuchs was able to obtain reliable accounts, amounts to 109, and he remarks that this is very nearly the average number per year, if compared to his annual compilations, which now extend over a period of thirteen years. They were distributed over the seasons of the year as follows:—

December, January, February ...	33 earthquakes.
March, April, May	31 ,,
June, July, August	11 ,,
September, October, November ...	34 ,,

On fifteen days several earthquakes occurred simultaneously in different places. Certain districts, such as Peru, Bolivia, Tokiô (Japan), the Island of Ooshima, Hawaii, &c., were visited by real earthquake periods, consisting of a large number of more or less violent shocks and detonations, while in others several earthquakes, separated by long periods of tranquillity, were observed. Among the latter we note—

Judenburg (Styria): January 4, December 27 and 28.
Western Odenwald: January 2 and 10.
Wald (Styria): January 12, September 5.
Rattenberg (Tyrol): April 8, October 11.
Bad Tüffer (Styria): April 4, 7, 24, 25, September 12.
Callao: April 22, May 14, October 9.
Western Switzerland: May 2, October 8, November 30.
Lisbon: November 1 and 4, December 22.

The earthquakes in Switzerland spread over a very considerable area. The first shocks on May 2 began near the Lake of Zürich and proceeded in three directions, viz., as far as Glarus and St. Gallen in the east, Mühlhausen in Alsace in the west, and the Black Forest in the north. They were followed by others more violent, and even more widely spread, on October 8. These were felt most severely at Geneva, where many chimneys were thrown to the ground; but they were distinctly noticed in the whole canton of Geneva, as well as in the Vaud, the Valais, Neufchatel, Berne, Freiburg, and Basel, and also in the French departments of Drôme, Isère, Rhone, Savois, Aix, Jura, Doubs, and even at Mühlhausen in Alsace. The extent of this earthquake towards the west was therefore a far more considerable one than towards the east, where the Alps seem to have hindered its progress; only in the broad Rhone Valley it was felt as far as Sitten. This is all the more remarkable since the Jura Mountains seem to have been without influence regarding its progress in the west. The greatest breadth of the area where the phenomenon was noticed, *i.e.* from Lyons to Sitten, measures some 200 kilometres, while its greatest length, *i.e.* from Valence to Mühlhausen, is 337 kilometres.

Another earthquake of large extension was the one felt on April 4 in the Eastern Alps; it was observed from Lower Styria as far as the junction of the Save with the Danube.

The most violent earthquake of all was the one which occurred on the South American coast on May 9, and in its whole course, as well as with regard to the minor phenomena which accompanied it, it can be compared only to the earthquake which occurred in the same region on August 13, 1868. We gave at the time details concerning this disastrous occurrence.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

At the distribution of prizes at the Yorkshire College last Friday the reports were, on the whole, satisfactory, though the institution has yet much to struggle against. Its great want is want of funds, for, though it has had many generous givers, it takes a great deal of money to start an institution of such magnitude. The college, however, seems extending its influence,